Improved Earthquake Safety for the Wasatch Front

Volume 21, Number 2-4—2006

Fault Line Forum

USSC

INSIDE THIS ISSUE:

Calendar of Events

APRIL 2006

7
Utah Seismic Safety Commission Meeting
Salt Lake City, Utah

18-22
100th Earthquake Conference
San Francisco, California

AUGUST 2006

17-18
Office of Emergency Services Public Officials Conference
Park City, Utah

STATUS REPORT UNREINFORCED MASONRY BUILDINGS AD HOC COMMITTEE

By Barry Welliver

The Utah Seismic Safety Commission's ad hoc committee on unreinforced masonry buildings has developed a resolution (On Page 2) outlining the significant dangers of older existing brick buildings within the state of Utah. This effort focuses on this dormant threat within our communities and calls for measures to inventory, prioritize and make recommendations to help lessen the significant risk due to these buildings.

The resolution was approved by the commission at its October 2005 quarterly meeting and presented to the Government Operations Interim Committee (GOIC) on November 9, 2005.

Originally slated as a ten minute information item to the GOIC committee at the end of their agenda, it quickly slipped past the mark as legislators asked questions about its need and impact. Representative Michael Morley and I stressed the importance of acknowledging this danger and finding equitable solutions which will progressively reduce the threat.

Ultimately, the GOIC committee was not obliged to take action on the resolution since it was not on their regular agenda, however the issue received a healthy airing among the legislators and helped focus some of the concerns as well as identify proponents.

Among the concerns was the potentially damaging effect or "unintended consequences" of identifying dangerous structures. This sentiment was shared by several legislators as they debated the value of the proposed inventory. It was addressed by the notion that the inventory was to be used as a tool to help quantify the potential problem and the information collected was not to be generally available for purposes of identifying specific buildings.

The inventory, which is based on the document "FEMA 154 –Second Edition- Rapid Visual Screening", is envisioned as a means to quickly categorize buildings which need additional study as well as to screen out "good" structures. This work could then be used to help advise the state and individuals of the magnitude of the potential problem and create a framework to move toward solutions to address the issue before a damaging earthquake makes its imprint.

Several legislators also saw the educational value of an inventory and agreed that we should work toward solutions beforehand and not be unprepared for the consequences. There were wide ranging suggestions from providing useful information to property owners to creating tax incentives for retrofit work.

The meeting concluded with our request that the Government Operations Interim Committee consider adopting a similar resolution (or create a study resolution) to help endorse the need for mitigation of dangerous buildings.

Cont. on Page 2

UNREINFORCED MASONRY BUILDINGS RESOLUTION

This is the URM Resolution that was unanimously approved by the USSC Commission.

SPONSOR: UTAH SEISMIC SAFETY COMMISSION

July 15, 2005

Whereas the State of Utah is susceptible to powerful, damaging earthquakes;

Whereas the Federal Emergency Management Agency (FEMA) has ranked Utah sixth in projected annualized earthquake loss in the United States;

Whereas much of the existing building stock within the state was constructed under codes and standards that did not recognize this hazard;

Whereas more than eighty percent of the state's population is located in areas subject to large earthquakes;

Whereas a major seismic event will result in catastrophic loss of life, property, and business in the state;

Whereas one of the state's primary responsibilities is to safeguard the safety and welfare of its citizens;

Whereas unreinforced masonry buildings (URM's) are among the most dangerous structures in a strong earthquake;

Whereas there is a large, but unquantified, inventory of such URM buildings in seismically active areas; and

Whereas recognizing and anticipating future catastrophic events, and preparing for recovery from such events is in the best interest of the citizens and the state,

Now therefore, be it resolved that the Utah Seismic Safety Commission undertake to compile an inventory of URM's to quantify the extent of the problem in the state.

Be it further resolved that the Utah Seismic Safety Commission recommend priorities to address the problem in a manner that will most effectively protect the lives, property, and the economy of the state of Utah.

Be it further resolved that the Utah Seismic Safety Commission make recommendations for ameliorating the URM problem in the state.

Be it further resolved that copies of this resolution be sent to the Utah House of Representatives, the Utah Senate, the Governor, the President of the Structural Engineers Association of Utah, and the President of the Utah Chapter of the American Institute of Architects.

Utah Seismic Safety Commission Meeting Notes

April 22, 2005 by Amisha Lester

On April 22, 2005, the Utah Seismic Safety Commission held it's quarterly meeting in Salt Lake City. Barry Welliver asked for the Commission to have an open discussion on the USSC progress report. Each Commissioner has been tasked to write their perspective, keeping it simple and precise, and sending it to Barry Welliver by June 24, 2005. These one page perspectives should include a meaningful report on what is felt to be our mission and vision that can be included in the progress report. An intern is to be selected and to start drafting the report by the next USSC meeting.

The Commission discussed the resolution recognizing the URM building hazards in Utah and a table of contents that includes the committee's tasks put together by the URM ad hoc committee. Several members suggested the resolution may be cast in the form of a motion at our next meeting with the intention of sending it to the legislature as recommendations on how to deal with the existing URM hazards in the state.

The table of content lists the committee members and their tasks that they will be working on for the paper. The ad hoc committee includes Barry Welliver, Carl Eriksson, Matt Cassel, and Darlene Batatian, Ryan Smith and Steven Bartlett.

Barry Welliver let the Commission know that he is still interested in being nominated for Chair for the coming year. Barry encouraged anyone that is interested in being nominated for Chair or Vice-Chair to please come forward.

Other Commission Notes...The Commission discussed having meetings that would allow tours of buildings that are under going seismic upgrades. Possible tours of the Tabernacle building and the Marriott Library was discussed. The Commission will be taking a tour of the State Capitol for the next meeting along with a possible lunch.

Bob Carey spoke on the Earthquake Preparedness Week that was held on April 3-9, 2005. The signing of the declaration was much different then in past years. Governor Hunstman engaged the group more than other Governors in years past. He asked many questions and was curious about Utah's future risks to earthquake. Walter Arabasz suggested having a placard that would define who we are and what we represent. Walter also recommended always being prepared to verbalize critical points when meeting public officials.

Bob Carey, Gary Christenson and Rick Allis spoke on the WSSPC updates. The Capitol, the Marriott Library and the Tabernacle are being considered for future nominations for WSSPC awards. The 2005 WSSPC Conference is going to be held in Boise, Idaho on September 11-14, 2005. The conference will be smaller than last year's national conference in St. Louis. State reports will be given during the conference and posters will be displayed during the break out sessions in the display area. The concept for the poster will be given in the July meeting. For more information regarding the conference, you can log on to www.wsspc.org.

Gary Christenson gave a brief report on the 2005 Working Group meeting. The working groups have met annually and consist of seismologist, geotechnical engineers and geologist active in earthquake engineering since 2003. During these meetings these working groups discussed existing, new and future projects and set priorities. Gary handed out a list of priorities that were set for each working group.

Gary spoke on the IBC ground-shaking maps. These are maps using the US Geological Survey National Seismic Hazard Maps that illustrate the levels of ground shaking here in Utah. The issue is when or if to make hard copies of these maps and distribute them. Having the maps accessible on the web is felt to be he best option. Another option is having the maps in a PDF format for emailing. Some hard copies are still to be printed for distribution. Maps include Salt Lake, Weber, Davis and Utah counties at the present time. The maps will be statewide following adoption of the 2006 IBC.

Bob Carey gave an update on the UGS-sponsored teacher workshops. The workshops are geared towards 5th and 9th grades. One was held in Salt Lake and the other in St. George with 18 participants in each. Teachers were able receive continuing education credit from the State Office of Education for the two day workshop. More advanced workshops are being planned throughout the state.

Bob Carey gave an update on the student research grant program. The group out of Summit County will be going to Yellowstone and have expanded their research to have a more geology. Bryant Middle School had to withdraw from the program due to a family illness.

UNIVERSITY OF UTAH QUARTERLY SEISMICITY SUMMARY

EARTHQUAKE ACTIVITY IN THE UTAH REGION
January 1 – March 31, 2005

by R. Burlacu, P. M. Roberson, and M. Howell with contributions by W. J. Arabasz, S. J. Nava, J. C. Pechmann, J. E. Hoffman, J. M. Hale, and K. L. Pankow
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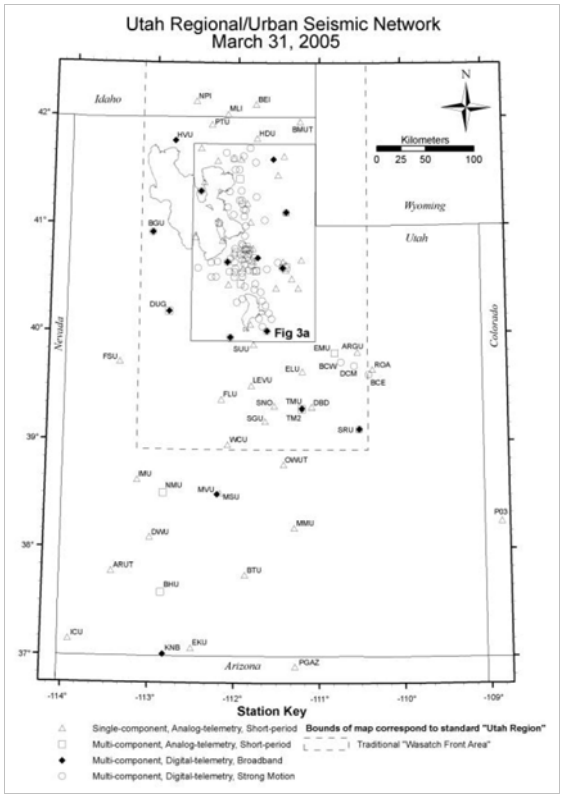

During the three-month period January 1 through March 31, 2005, the University of Utah Seismograph Stations (UUSS) located 315 earthquakes within the Utah region (Figure 1). The total includes one earthquake in the magnitude 3 range, and 20 earthquakes in the magnitude 2 range. Earthquakes of magnitude 3.0 or larger (plotted as stars and specifically labeled on Figure 1) are listed below. Two earthquakes were reported felt during the report period (see Table 1, a cumulative tabulation of felt earthquakes in the Utah Region during 2005). Additional information on earthquakes within the Utah region is available from the University of Utah Seismograph Stations.

Online Information
A complete copy of this report, including maps and the earthquake catalog, is available on the UUSS Web site at *http://www.seis.utah.edu/catalog/quarterly.shtml*. ShakeMaps—computer maps of the ground shaking produced by an earthquake—are automatically produced by UUSS for earthquakes of magnitude 3 and larger within the Wasatch Front urban area. The ShakeMaps are accessible on the UUSS Web page at *http://www.seis.utah.edu/shake*. Earthquakes during 2005 for which ShakeMaps are available are indicated in Table 1. For earthquakes of magnitude 3 and larger in the Utah region, the U. S. Geological Survey automatically posts a Community Internet Intensity Map (CIIM) on its "Did You Feel It?" Web page at *http://pasadena.wr.usgs.gov/shake/imw*. We urge anyone who feels an earthquake to report their observations on this interactive Web site; felt information is available by zip code on the CIIM site or can be obtained from UUSS directly.

Earthquakes of Magnitude 3.0 or Larger
ML 3.5 March 14 17:21 MST 6 mi WNW of Fredonia, AZ (felt; see Table 1)

Other Notable Seismicity
During the report period, there were two notable spatial clusters of earthquake activity (labeled A–B in Figure 1). For reporting purposes, we define a cluster as ten or more earthquakes occurring within a 10- km (6-mile) radius during the report period. Referring to the epicenter map (Figure 1), these include the following—from north to south (all dates below are UTC unless otherwise noted):

A. A cluster of 43 earthquakes (-0.2 £ M £ 2.7) occurred about twenty five miles WNW of Garland, UT (~41 miles WNW of Logan). Thirty of these events, including the magnitude 2.7 event, occurred on March 31.

B. Fourteen earthquakes (0.1 £ M £ 2.0) clustered about four miles ESE of Heber City, UT (~23 mi NNE of Provo). In Figure 1, the locally clustered seismic events within a radius of approximately 30 miles of Price, together with a localized cluster about 50 miles to its southwest, are associated with known areas of underground coal mining and are interpreted to be mining-related. These include a total of 149 located shocks (0.7 £ M £ 2.3) that occurred throughout the report period.

University of Utah Quarterly Seismicity Summary

EARTHQUAKE ACTIVITY IN THE UTAH REGION
April 1 – June 30, 2005

by R. Burlacu, P. M. Roberson, and M. Howell with contributions by W. J. Arabasz, S. J. Nava, J. C. Pechmann, and K. L. Pankow University of Utah Seismograph Stations
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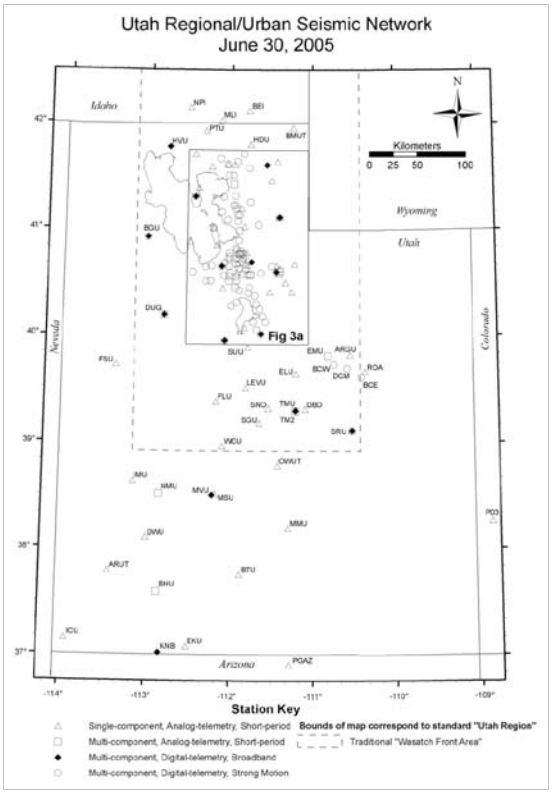

During the three-month period April 1 through June 30, 2005, the University of Utah Seismograph Stations (UUSS) located 363 earthquakes within the Utah region (Figure 1). The total includes two earthquakes in the magnitude 3 range, and 47 earthquakes in the magnitude 2 range. Earthquakes of magnitude 3.0 or larger (plotted as stars and specifically labeled on Figure 1) are listed below. One earthquake was reported felt during the report period (see Table 1, a cumulative tabulation of felt earthquakes in the Utah Region during 2005). Additional information on earthquakes within the Utah region is available from the University of Utah Seismograph Stations.

Online Information

A complete copy of this report, including maps and the earthquake catalog, is available on the UUSS Web site at *http://www.seis.utah.edu/catalog/quarterly.shtml*. ShakeMaps—computer maps of the ground shaking produced by an earthquake—are automatically produced by UUSS for earthquakes of magnitude 3 and larger within the Wasatch Front urban area. The ShakeMaps are accessible on the UUSS Web page at *http://www.seis.utah.edu/shake*. Earthquakes during 2005 for which ShakeMaps are available are indicated in Table 1. For earthquakes of magnitude 3 and larger in the Utah region, the U. S. Geological Survey automatically posts a Community Internet Intensity Map (CIIM) on its "Did You Feel It?" Web page at *http://pasadena.wr.usgs.gov/shake/imw*. We urge anyone who feels an earthquake to report their observations on this interactive Web site; felt information is available by zip code on the CIIM site or can be obtained from UUSS directly.

Earthquakes of Magnitude 3.0 or Larger

ML 3.3 May 18 13:21 MDT 13 mi NW of Evanston, WY
ML 3.6 June 24 07:01 MDT 18 mi N of Roseville, UT (felt; see Table 1)

Other Notable Seismicity

During the report period, there were three notable spatial clusters of earthquake activity (labeled A–C in Figure 1). For reporting purposes, we define a cluster as ten or more earthquakes occurring within a 10- km (6-mile) radius during the report period. Referring to the epicenter map (Figure 1), these include the following—from north to south (all dates below are UTC unless otherwise noted):

A. A cluster of 13 earthquakes ($-0.6 \le M \le 1.2$) occurred about five miles WSW of Kamas, UT (~29 miles E of Salt Lake City).

B. Fourteen earthquakes ($-0.1 \le M \le 2.4$) clustered about four miles E of Heber City, UT (~25 mi NNE of Provo). Eight events, including the 2.4 event, occurred between June 2 and June 4.

C. A cluster of 24 earthquakes ($1.4 \le M \le 3.6$) occurred about eighteen miles N of Orderville, UT (~31 miles E of Cedar City). Seventeen events, including the 3.6 event, occurred between June 23 and June 26. In Figure 1, the locally clustered seismic events within a radius of approximately 30 miles of Price, together with a localized cluster about 50 miles to its southwest, are associated with known areas of underground coal mining and are interpreted to be mining-related. These include a total of 189 located shocks ($0.8 \le M \le 2.4$) that occurred throughout the report period.

UNIVERSITY OF UTAH QUARTERLY SEISMICITY SUMMARY

EARTHQUAKE ACTIVITY IN THE UTAH REGION
July 1 – September 30, 2005

by R. Burlacu, P. M. Roberson, and M. Howell with contributions by W. J. Arabasz, S. J. Nava, J. C. Pechmann, and K. L. Pankow
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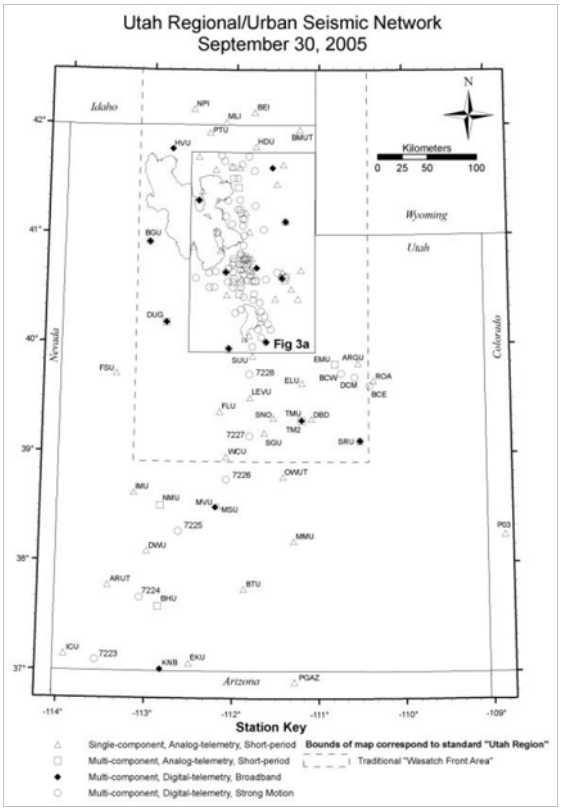

During the three-month period July 1 through September 30, 2005, the University of Utah Seismograph Stations (UUSS) located 452 earthquakes within the Utah region (Figure 1). The total includes eight earthquakes in the magnitude 3 range, and 39 earthquakes in the magnitude 2 range. Earthquakes of magnitude 3.0 or larger (plotted as stars and specifically labeled on Figure 1) are listed below. Eight earthquakes were reported felt during the report period (see Table 1, a cumulative tabulation of felt earthquakes in the Utah Region during 2005). Additional information on earthquakes within the Utah region is available from the University of Utah Seismograph Stations.

Online Information

A complete copy of this report, including maps and the earthquake catalog, is available on the UUSS Web site at *http://www.seis.utah.edu/catalog/quarterly.shtml*. ShakeMaps—computer maps of the ground shaking produced by an earthquake—are automatically produced by UUSS for earthquakes of magnitude 3 and larger within the Wasatch Front urban area. The ShakeMaps are accessible on the UUSS Web page at *http://www.seis.utah.edu/shake*. Earthquakes during 2005 for which ShakeMaps are available are indicated in Table 1. For earthquakes of magnitude 3 and larger in the Utah region, the U. S. Geological Survey automatically posts a Community Internet Intensity Map (CIIM) on its "Did You Feel It?" Web page at *http://pasadena.wr.usgs.gov/shake/imw*. We urge anyone who feels an earthquake to report their observations on this interactive Web site; felt information is available by zip code on the CIIM site or can be obtained from UUSS directly.

Earthquakes of Magnitude 3.0 or Larger

ML 3.5 July 20 01:06 MDT 20 mi SSW of Kanosh, UT (felt, see Table 1)
ML 3.0 July 20 08:44 MDT 20 mi NE of Milford, UT (felt, see Table 1)
ML 3.0 July 20 15:42 MDT 20 mi NE of Milford, UT
ML 3.3 July 22 23:37 MDT 10 mi E of Richmond, UT (felt; ShakeMaps and CIIM intensity map available, see Table 1)
ML 3.7 July 29 14:46 MDT 2 mi E of Richfield, UT (felt; CIIM intensity map available, see Table 1)
ML 3.1 August 20 06:21 MDT 15 mi WNW of Escalante, UT (felt; CIIM intensity map available, see Table 1)
ML 3.0 September 5 03:31 MDT 7 mi ENE of Henefer, UT (ShakeMaps available) M_L 3.0 September 20 00:53 MDT 15 mi SW of Tropic, UT (felt; CIIM intensity map available, see Table 1)

Other Notable Seismicity

During the report period, there were seven notable spatial clusters of earthquake activity (labeled A–G in Figure 1). For reporting purposes, we define a cluster as ten or more earthquakes occurring within a 10- km (6-mile) radius during the report period. Referring to the epicenter map (Figure 1), these include the following—from north to south (all dates below are UTC unless otherwise noted):

A. A cluster of 16 earthquakes (0.4 £ M £ 1.9) occurred about eleven miles WSW of Bear River City,

Cont. on Page 10

WESTERN STATES SEISMIC POLICY COUNCIL 2005

BY BOB CAREY

The 2005 WSSPC Conference, "NEHRP's NEXT DECADE, Challenges for Implementation", was held in Boise, Idaho. Two USSC Commissioners gave presentations at the conference. **Barry Welliver's** presentation on existing building was part of the session on "Setting Priorities". This session explored issues in implementing seismic safety at the local level given competing needs and economic challenges**. Walt Arabasz's** ANSS presentation was part of the session on "Implementing ANSS". The session looked at the process and progress of implementing the ANSS and the role of regional and local seismic network. **Bob Carey** was a session leader for the session on "Changing Behavior". This session examined the differing approaches to risk and how perceptions are changes. All sessions had panel discussions.

The Commission, the Utah Geological Survey and the Utah Division of Emergency Services were recognized for some of their past achievements by WSSPC's Awards in Excellence. The Commission and the DES's "Student Research Grant Program" received the award in the category "Education Outreach to Schools". UGS's sponsoring of the "Utah Quaternary Fault Parameters Working Group" received the award in the category "Research". The Commission's Geoscience Standing Committee's booklet, "Utah Earthquake Ground-Shaking Maps: Which One Do I Use?" received the award in the category, "Response Plans/Materials".

The WSSPC field trip participants listening to a presentation about the Boise River Floodplain.

Craig Depolo, Nevada, and Mike Stickney, Montana, view a faulted outcrop on the WSSPC field trip.

Utah Seismic Safety Commission Tours Capitol Retrofit

The Commissioners and guests of the USSC toured the Capitol retrofit project. A briefing, provided by Dave Hart, Executive Director of the Capitol Preservation Board, gave the group insights into the intricacies of the project. The tour took participants to several areas inside the building. There the participants were able to view the various stages of the project depending on what part of the building they were observing. Several different structural strengthening techniques are being undertaken to on the building, but the most obvious is the base isolation system. In addition to the retrofit, the Capitol's interior is being renovated back to its original look when the building was dedicated in 1916.

Part of the USSC tour of the Capitol viewing the new foundation.

Left is a base isolator mounted to concrete with building jacks on the right.

Utah Seismic Safety Commission Meeting Notes

July 15, 2005 by Amisha Lester

On July 15, 2005, the Utah Seismic Safety Commission held it's quarterly meeting in Salt Lake City. Barry Welliver and the Commission discussed the USSC Progress Report. Barry and Bob Carey have met with the intern to compile information and prepare the document. Ten out of a possible fifteen Commissioners have responded with their input for the report. Bob and the intern are preparing this information for the document. There are 23 "retrospective" topics for potential inclusion in the report. Barry gave a handout that tasked Commissioners to expand on certain topics and respond by the first of September. An October deadline has been made to have the report in a rough draft form.

Barry Welliver began his discussion with a handout that includes a resolution recognizing the URM building hazard in Utah. The resolution is a tool to address the concerns and lists steps to resolve those concerns. This resolution will be used as a template or a guide to communicate to the legislature, in hopes to gain endorsement from the state. A sub-group is to compile an inventory of the URMs within the state. The Commission passed a motion to adopt the resolution.

Other Commission Notes...Rick Allis reported on the Western States Seismic Policy Council (WSSPC) awards nominations and 2005 meeting. Three out of four nominations from Utah will be receiving WSSPC Awards in Excellence. Those receiving recognition are the UGS Quaternary Fault Parameters Working Group, the USSC Ground Shaking Brochure, and USSC/DES Student Research Grant Program. Expanding WSSPC to include the five or six state seismic safety commissions will be discussed at the Boise meeting.

Representative Morley took over the election portion of the meeting. He asked for a motion to nominate Barry Welliver for Chair and Peter McDonough and Rick Allis as Vice Chairs for the coming year. All were elected unanimously.

Gary gave a brief report on the IBC ground-shaking maps. A one-page general-public explanation has been posted on the UGS web-site. The USSC web-site will also have a link to the UGS web-site. Barry Welliver suggested to create a letter to endorse this tool for building officials, realtors, developers, etc.

Utah Seismic Safety Commission Meeting Notes

October 28, 2005 by Amisha Lester

On October 28, 2005, the Utah Seismic Safety Commission held it's quarterly meeting in Salt Lake City. Fred Turner, structural engineer with the California Seismic Safety Commission, gave a presentation and handouts on their state's experience with unreinforced masonry buildings (URM's). He gave a historical overview of their programs to mitigate URM's and discussed the successes and pitfalls associated with the work

Matt Cassel reported on the URM resolution. The resolution is in the final stages of completion. The Commission is hopeful to move this resolution through the Legislature in November as an information insert. Representative Morley will arrange for the presentation of the resolution to the interim Government Operations Standing Committee.

The Commission discussed priorities for future USSC meetings outside of the Salt Lake City area. For an overnight trip to Cedar City, Gary Christenson has estimated $2000 for 15 people to attend. The Commission would like to have a joint meeting with the Nevada Seismic Safety Council possibly in Wendover, Mesquite or Las Vegas. The USSC planning committee will continue to work on the possibility of future meetings outside of the Salt Lake City area.

Walter Arabasz gave an update on the proposal to expand southwest Utah earthquake instrumentation. Walter gave a handout on the concept proposal for expanding seismic instrumentation and rapid earthquake information capabilities in the St. George and Cedar City areas and rural southwest Utah. Endorsement from the Commission for the proposal was discussed.

Other Meeting Notes...Rick Allis reported on the Western States Seismic Policy Council (WSSPC) Annual Meeting in Boise, Idaho. Seventy plus people attended the annual meeting. The meeting was more geologically focused which brought more interest among the geologist members. In the December board meeting they will be discussing the next annual meeting. Seismic safety commissions as well as emergency managers and state geologists can now become members of WSSPC.

Bob Carey discussed the USSC workshop to be held on December 13, 2005 at the Salt Lake County Emergency Operations Center. This will be a half-day workshop that is geared towards the emergency planning community. Topics will include a presentation on a Wasatch Front M 7 scenario earthquake, HAZUS analysis of the scenario earthquake, ShakeMap and ShakeCast, FEMA response to Katrina, and a panel discussion.

Barry Welliver discussed the 2000-2004 USSC Progress Report. The paperwork is in progress to hire the intern for the report. The report will not be finalized until 2006, and will be expanded to include all work from 2005.

Former Commissioner Honored

By Bob Carey

The Commission at its July meeting honored Ann vonWeller for her contributions to the Commission. Ann, representing the League of Cities and Towns, served as a commissioner from 2000 to 2003. While serving on the Commission, Ann's day job is the Chief Building Official for Murray City. Her resignation was the result of being elected to the Board of Directors of the International Code Council as Vice President.

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University of Utah Quarterly Seismicity Summary Continued

UT (~28 miles WSW of Logan). Seven events, including the 1.9 event, occurred on August 9.

B. Ten earthquakes (0.2 £ M £ 2.8) clustered about three miles NNE of Alta, UT (~18 mi ESE of Salt Lake City). Nine events, including the 2.8 event, occurred between August 15 and August 17.

C. A cluster of 28 earthquakes (0.0 £ M £ 1.7) occurred about five miles WSW of Kamas, UT (~29 miles E of Salt Lake City).

D. A cluster of 11 earthquakes (1.0 £ M £ 2.4) occurred about eighteen miles N of Holden, UT (~39 mi NNW of Richfield). All events occurred on September 1.

E. A cluster of 10 earthquakes (1.0 £ M £ 3.7) occurred about 2 miles W of Richfield. Nine of these events, including the 3.7 event, occurred between July 29 and August 1.

F. A cluster of 15 earthquakes (1.0 £ M £ 3.5) occurred about nineteen miles NNW of Beaver, UT (~36 mi SW of Richfield). Seven events, including the 3.5 event, occurred between July 20 and July 22.

G. A cluster of 13 earthquakes (1.2 £ M £ 2.3) occurred about eighteen miles N of Orderville, UT (~31 mi E of Cedar City). Six events, including the 2.3 event, occurred on August 17. In Figure 1, the locally clustered seismic events within a radius of approximately 30 miles of Price, together with a localized cluster about 50 miles to its southwest, are associated with known areas of underground coal mining and are interpreted to be mining-related. These include a total of 191 located shocks (0.6£ M £ 2.3) that occurred throughout the report period.